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Does project-level aid for water and sanitation improve child health outcomes? Evidence from household panel data in Uganda

Lynda Pickbourn[a]*, Raymond Caraher[a], and Léonce Ndikumana[a]

Abstract: Empirical studies on the effectiveness of aid to the water, sanitation, and hygiene sector (WASH aid) have focused primarily on access to these services as the benchmark for evaluating the effectiveness of aid in this sector. Given the importance of WASH services for public health outcomes, the effectiveness of WASH aid should also be evaluated in terms of its impact on health outcomes. This is especially important in low- and middle-income countries where achieving sustained improvements in child health outcomes remains a challenge. This paper uses geocoded sub-national data on the location of WASH aid projects in Uganda in conjunction with six waves of nationally representative household-level panel survey data to examine the impact of aid-funded WASH projects on the probability of stunting among Ugandan children and infants. Analysing aid effectiveness at the sub-national level avoids the problems of cross-country heterogeneity in aid effectiveness that plagues other studies. Results of the difference-in-differences regression analysis suggest that proximity to an aid-funded WASH project reduces the probability of stunting by 14–21 per cent. The results suggest that scaling up aid to the WASH sector can help improve child health outcomes in the country.

Key words: aid, public health, water and sanitation, childhood stunting, difference in differences, Uganda

JEL classification: I15, O12, O55, F35

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1 Introduction

Child stunting, or the impaired growth that children experience from poor nutrient intake, absorption, or utilization, remains a significant impediment to human development. Children are considered stunted if the length- or height-for-age is more than two standard deviations below the WHO Child Growth Standards median (WHO 2014). Although the number of children affected by stunting globally has decreased since 1990, the rate of decline has been unequal across regions and sub-regions and an estimated 21.3 per cent of children, or 144 million to 162 million children worldwide, are stunted (Waller et al. 2020; WHO 2014). Currently, Africa and Asia account for nearly the entirety of the global burden of stunting, and sub-Saharan Africa, with the highest regional prevalence of 32.7 per cent (representing 57 million children), is the only region that has seen an increase in the number of children who are stunted, even as the prevalence of stunting in the region has continued to fall (Waller et al. 2020; WHO 2014).

Stunting in early life has profound and long-lasting adverse consequences. In addition to strong negative associations between stunting and cognitive ability and educational performance, adults who were stunted in the first 1,000 days of life have been shown to have lower productivity and wages as well as increased risk of chronic metabolic disease compared to adults who were not stunted (WHO 2014).

While efforts to reduce stunting have focused mostly on improving nutrition, there is mounting evidence that improved water, sanitation, and hygiene (WASH) services are critical to the success of these efforts. Frequent diarrhoea and environmental enteric disorder (EED) are important causes of malnutrition and stunting in young children, suggesting that poor WASH services may be a major contributor to child stunting, especially in sub-Saharan Africa (Waller et al. 2020). However, universal access to safe and affordable drinking water remains an elusive goal in many parts of the developing world, and especially in SSA, which is home to half of the 771 million people who lack access to basic drinking water (UN 2021; UNICEF/WHO 2019; UN-Water 2021; WHO/UNICEF 2021). Inadequate financing of water and sanitation investments remains a major challenge in the region. The majority of SSA countries have indicated a lack of sufficient domestic resources to meet the financing requirements for even their own domestic targets for WASH services, notwithstanding the higher targets set by the Sustainable Development Goals (SDGs), indicating a need for increased development assistance to the WASH sector (UN-Water/WHO 2017, 2019). Although the region received the largest share (34 per cent) of official development assistance (ODA) disbursements for the water sector of any developing region in 2019, aid to the WASH sector is still less than 5 per cent of total aid disbursements to the region (UN-Water 2021). In order to justify targeting more resources to water and sanitation, aid donors need more evidence on the effectiveness of WASH aid in recipient countries.

However, economists have devoted relatively little attention to the question of aid effectiveness in the WASH sector and, to the extent that they have done so, most studies have focused on population access as the benchmark for evaluating WASH aid effectiveness. However, given the centrality of WASH services to health outcomes, the question of whether increasing ODA to the WASH sector in African countries will result in improved health outcomes remains especially important, both for the region as a whole and for individual countries within the region.

This paper combines geocoded sub-national data on the location of WASH aid projects in Uganda with six waves of nationally representative household-level panel survey data covering the period 2005–16 to examine the impact of WASH aid on child health outcomes. Specifically, we use a quasi-experimental approach based on difference-in-differences regression estimations to examine whether proximity to aid-funded WASH projects reduces the probability of a child being stunted. We supplement the usual before–after specification with the construction of cohort-based control groups, following Cengiz et al. (2019) and Deshpande and Li (2019). This enables us to better link stunting outcomes to the proximity of an aid-funded WASH project.

The analysis of WASH aid effectiveness in improving health outcomes at the sub-national level offers several advantages over a cross-country approach. For one thing, WASH aid is typically allocated to fund specific projects in different countries. The impact of these projects on health outcomes is likely to be highly localized, while the effect on aggregate outcomes may be negligible (Dreher and Lohmann 2015). For conceptual and empirical reasons, therefore, the effectiveness of aid should be examined at the point of the intervention (Pickbourn and Ndikumana 2013). In addition, exploiting sub-national data on the location of aid projects in combination with comprehensive household surveys allows researchers to use quasi-experimental techniques to gauge the impact of aid on health outcomes at the micro level by comparing these outcomes across sub-national locations that receive aid projects and those that do not (Odokonyero et al. 2018). Furthermore, the use of household surveys in sub-national studies can provide information on determinants of health outcomes that may not be available in more aggregated datasets. Finally, from a policy standpoint, cross-country studies provide only an estimate of the average effect of aid across very different countries; policy decisions about where and how to allocate aid should be based on far more granular evidence that can only be obtained from sub-national studies.

Uganda provides an interesting case study of the impact of WASH aid on health outcomes. Despite a slight decrease of 4 percentage points in the prevalence of stunting between 2011 and 2016, a third of children under the age of five in Uganda are stunted (USAID 2021). The country's efforts to reduce stunting have primarily focused on policies to improve nutrition as, for example, in the Uganda Nutrition Action Plan (UNAP) II (2020/2021–2024/2025). Although expanding access to water and sanitation features prominently in the country's constitution and in its development plans (Alabaster and Kručková 2015; Tsimpo and Wodon 2018), the role of WASH in reducing child stunting rates in Uganda has not received much attention. Significant disparities in access to improved water and sanitation exist between rural and urban areas and between rich and poor households (Alabaster and Kručková 2015; Tsimpo and Wodon 2018). These disparities in WASH services are analogous to disparities in the prevalence of stunting. Qualitative studies of water access in Uganda point to inadequacy and unaffordability of the water supply as well as lack of functionality of the water infrastructure as recurrent problems for Ugandan households (Alabaster and Kručková 2015; Tsimpo and Wodon 2018).

Notwithstanding these challenges, funding to the sector as a share of Uganda's national budget has continued to lag behind other sectors, averaging 2.9 per cent between 2015 and 2018 (Burr 2019; Tsimpo and Wodon 2018). This was due in part to a steady decline in WASH ODA as a share of total ODA from about 9.9 per cent in 1990–94 to a low of about 4.3 per cent in 2010–14, even as total aid to the country remained fairly constant, reflecting weak donor support for the sector (Table A1). The government's Strategic Sector Investment Plan estimates that a WASH investment of

US$935 million a year is required to meet the SDG targets of universal access to safely managed water and sanitation by 2030; this is over three times the current level of investment in WASH service provision (Burr 2019). In its 2018 Sector Performance Report, the government of Uganda concedes that it will be unable to fulfil the SDG 6 target of universal access to safe drinking water by 2030 without significant external funding (DANIDA 2019). Our previous work on Uganda has already shown that proximity to aid-funded water projects can help to increase household access to water, although longer travel and wait times at the points of water access suggest that the supply of aid-funded WASH projects remains inadequate relative to population needs (Pickbourn et al. 2022). The question of whether increased aid to the water sector can also help to improve child health outcomes, as measured by the prevalence of child stunting, remains highly relevant given the size of the gap in WASH financing in Uganda and declining donor support for the sector.

The evidence from this study suggests that WASH aid indeed yields improvements in child health outcomes. Specifically, the regression results indicate that being born in the vicinity of a completed aid-funded WASH project significantly reduces a child's probability of being stunted by 14 to 25 per cent. As expected, the impact dissipates as the distance from the aid project increases.

The remainder of the paper is organized as follows. The next section presents a survey of related literature. Section 3 presents the data and stylized facts. The empirical methodology is presented in Section 4 and the regression results are discussed in Section 5. Section 6 concludes.

2 Related literature

This paper builds on findings from two different strands of literature: the literature on aid effectiveness in the WASH sector and the literature on the link between access to WASH services and health outcomes.

2.2 Aid effectiveness in the WASH sector

Most studies so far of WASH aid effectiveness have focused on population access to these services as the benchmark for evaluating aid effectiveness and have relied on macro-level data and cross-country analysis, with mixed results. Some studies find no evidence that WASH aid has any impact on access to WASH services in developing countries (Bain et al. 2013; Botting et al. 2010; Wolf 2007). In contrast, Gopalan and Rajan (2016), Ndikumana and Pickbourn (2017), Pickbourn et al. (2022), and Wayland (2013) all find evidence that WASH aid has a positive impact on population access to water and sanitation services in both rural and urban areas in developing countries and in sub-Saharan Africa (see Gopalan and Rajan 2016, Gyimah-Brempong 2015, and Ndikumana and Pickbourn 2017 for detailed reviews of this literature). Ndikumana and Pickbourn (2017) also find evidence of cross-country variation in the effectiveness of WASH aid, pointing to the need for sub-national analysis to better understand the within-country effects of aid in this sector.

The relatively small number of studies that take a sub-national approach to the study of aid effectiveness in the water and sanitation sector do find a positive impact of WASH aid projects on access to water and sanitation. Wayland (2019) finds that households located near WASH aid projects in Malawi are significantly more likely to report using improved sources of drinking water and sanitation, although the impact is constrained by water availability, remoteness, and household income level. Using difference-in-differences regression analysis, Pickbourn et al. (2022) find that households located near aid-funded WASH projects in Uganda were more likely to use improved sources of water. However, these households also saw an increase in the time burden of water collection, as they had to travel longer distances, and also experienced longer wait times due to congestion at the water service points.

2.2 Access to WASH services and health outcomes

The importance of safe WASH services for public health is well known. Poor WASH services are associated with a high burden of infectious diseases, including, but not limited to, diarrhoeal disease. Prüss-Ustün et al. (2014) find that poor water services account for an estimated 500,000 deaths globally, while poor sanitation and hygiene services account for 280,000 and 300,000 deaths respectively. Poor quality WASH services have also been linked to other infectious diseases, including helminth infections, schistosomiasis, trachoma, respiratory infections, and maternal and reproductive infections (Cumming and Cairncross 2016: 93). Diarrhoeal disease remains a leading cause of death in children under the age of five, and several empirical studies have confirmed the importance of access to water and sanitation in reducing diarrhoea morbidity and mortality in infants and children under 5 (Esrey et al. 1988; Fewtrell et al. 2005; Fink et al. 2011; Gasana et al. 2002; Prüss-Ustün et al. 2008). Pickbourn and Ndikumana (2019) find that a 1 per cent increase in population access to improved sources of water is associated with 24 fewer deaths from diarrhoea per 1,000 live births among children under the age of five in sub-Saharan Africa.

2.3 WASH aid and health outcomes

Given that the relationship between safe WASH and health outcomes has been so well documented, the question of whether WASH aid projects in developing countries can result in better health outcomes remains highly relevant for evaluating the effectiveness of aid in the WASH sector. Yet, this question remains relatively understudied in the literature. While Bartram and Cairncross (2010) suggest that 'a reasonably well-implemented intervention in one or more of hygiene, sanitation, water supply or water quality, where pre-existing conditions are poor, is likely to reduce diarrhoeal diseases prevalence by up to a third', Wayland (2017), using an instrumental variable regression analysis on a panel dataset comprising 125 recipient countries over 20 years, finds that WASH aid was consistently associated with a reduction in the under-5 mortality rate in middle-income countries but not in low-income countries.

This paper contributes to the literature on the effectiveness of WASH aid in improving health outcomes by focusing on the impact of WASH aid on the probability of stunting. The most direct causes of stunting are inadequate nutrition and recurrent infections during the first 1,000 days of a child's life (beginning from conception), which cause poor nutrient intake, absorption, and utilization (WHO 2014). Protozoan and helminthic infections, diarrhoea and EED are biological causes of growth faltering, and undernutrition arising from inadequate access to food may be exacerbated by frequent infections (Waller et al. 2020). An extensive review of 59 papers published between 2008 and 2019 on the link between WASH and stunting in children under the age of two in sub-Saharan Africa finds that stunting is directly attributed to diarrhoea, EED, and undernutrition, and WASH interventions have been shown to reduce stunting rates, although the reasons for this are poorly understood (Waller et al. 2020). However, the question of how WASH interventions impact child health outcomes is by no means settled. Headey and Palloni (2019) note that while several studies find convincing evidence of WASH impacts on diarrhoea, impacts on child nutrition and mortality outcomes remain uncertain. The authors attribute this lack of clarity to the methodological limitations of the randomized control trials (RCTs) and observational studies that constitute the bulk of this literature. RCTs are hampered by low adoption of WASH interventions and short duration of exposure to WASH treatments, while cross-sectional studies are hampered by the fact that WASH exposure in these samples is not linked to specific interventions and may be correlated with confounding factors such as parental knowledge and preference, cultural norms, local economic development, historical infrastructure investment, quality of governance institutions, and environmental factors (Headey and Palloni 2019: 730). This study attempts to avoid some of these challenges by using a quasi-experimental approach in which WASH exposure is defined in terms of household proximity to an aid-funded WASH project.

3 Data sources and stylized facts

The primary data sources used in this study consist of six waves of the Uganda National Panel Survey provided by the Uganda Bureau of Statistics (UBOS 2009, 2011, 2012, 2014, 2016) and the AidData Uganda AIMS Geocoded Research Release Version 1.4.1 maintained by the Global Research Institute at William & Mary (AidData 2016).

The household survey data include the waves of 2005, 2009, 2010–11, 2011–12, 2013–14, and 2015–16. These surveys contain information about household composition and characteristics, resources, child health outcomes, and access to water and sanitation. Households are linked across survey waves with a unique identifier for the household. Due to changes in response codes across the surveys, relevant items were recoded to reflect as closely as possible the responses in the 2015–16 survey wave. Table A2 in the Appendix shows the questions for the survey items used in the analysis and how these items were coded.

The 2011–12 survey contains locational data which was anonymized by adding random error components to the longitude and latitude. Since such adjustments could cause matching errors in our analysis, confidential exact locational data for the households was obtained directly from the Uganda Bureau of Statistics. This data was provided for the most recent survey wave, so households are assumed to have stayed in the same location across survey waves. Locational data is merged with household data by matching villages within a given district and parish.

The geographically referenced data on aid-funded WASH projects is obtained from AidData and includes all geocoded WASH projects from Uganda's Aid Management Platform. Based on AidData's Water Supply and Sanitation Purpose Codes, these projects include the construction of wells and latrines as well as other drinking water and sanitation infrastructure, among others. Although it is possible that this dataset may underestimate the total amount of aid received for water and sanitation, this is the only source of geo-referenced aid data currently available. AidData codes each project with a geographic precision code which references the spatial coverage of the project, i.e., whether the project covers the entire country, a particular region, district, or village. Our analysis was limited to aid-funded WASH projects in 48 locations initiated between 2009 and

2014 with the most precise location information, i.e., those with a precision code of 1 (Table A3).[1] In other words, the analysis includes only projects that were installed at a precise location (for example, the construction of a well, borehole, or toilet and handwashing facility near a school or in a specific village). WASH projects which are funded at a district or higher-level administrative area (i.e., those with precision codes 2–6) are not associated with exact geographical coordinates for each component of the project and are therefore excluded from our analysis. The distance in kilometres from each household to each aid-funded WASH project in the final sample is computed using the Vincenty Ellipsoid great-circle distance method (Vincenty 1975).[2] Households are coded as treated if they fall within the relevant radius and the project is completed before a given survey wave starts. For example, a household which is within 10 km of an aid project that was completed in 2011 would be considered treated in the 2012 household survey and in subsequent editions of the household survey. Almost all of the aid-funded WASH projects used for the analysis were completed between 2011 and 2013 (Table 1). The projects were unevenly distributed across the country (Figure 1) and the amount of aid associated with different projects varies considerably (Table A3).

[Table 1 near here]

[Figure 1 near here]

Figure 2 shows stunting rates by region and by survey wave: stunting rates are consistently highest in the Western region and vary by survey year for the other regions. Figure 3 shows stunting rates by age group.

[Figure 2 near here]

[Figure 3 near here]

Table 2 shows the average minimum distance between households and the nearest project in each region and year. The average minimum distance is lowest in Kampala and highest in the Northern

[1] This corresponds to 14 separate projects. AidData assigns a precision code of 1 if the geographical coordinates of the project correspond to an exact location such as a populated place or a physical structure such as a school or health centre. This code may also be used for locations that join other locations to create a line such as a road, power transmission line, or railroad (AidData 2017))

[2] The R documentation on this method can be found at https://rdrr.io/cran/geosphere/man/distVincentyEllipsoid.html

region. Across the country, the average minimum distance to aid-funded WASH projects appears to have fallen over time.

[Table 2 near here]

4 Empirical approach

In this analysis, we focus on the stunting outcomes of infants and children under the age of five. In our first specification, we do a before–after comparison to examine the change in stunting rates for children born within a given radius of a project before the project's completion compared to those born after the project was completed. Specifically, we estimate a regression model specified as follows:

$$y_{hit} = \beta D_{hit} + \alpha_d + \delta_t + \Omega_{ht} + \mu_{it} \quad (1)$$

where y_{hit} equals one if child i in household h at time t is stunted according to the WHO definition for the child's age and size. D equals one if a child i in household h lies within a given radius from the aid-funded project at time t, and β is a measure of the effect on stunting rates for children born after a project's completion within a given radius. For example, for a radius between 0 km and 5 km, this specification is comparing the stunting rates for children within this radius but born one year prior to a project's completion to children also within this radius but born within one year after. The variable α is a district fixed effect and δ is a time fixed effect. The variable Ω_{ht} controls for household wealth and other demographic variables, and μ_{it} is a child-specific error term.

While it is a useful starting point, the before–after specification above does not incorporate a control group. If stunting rates are changing due to some factor other than proximity to a WASH aid project which is not captured by fixed effects or controls, the estimate of the effect of WASH aid on stunting will be biased. Therefore, it is important to form a control group to account for changes in stunting rates for the non-treated group.

One issue with defining a control group when the projects are rolled out in a staggered manner, as seen in Table 1, is how to define the relative age of each child. For example, if a child is born in 2011, are they born one year prior to a 2012 project or one year after a 2010 project? A basic difference-in-differences analysis would assign all children who are outside of a given radius to the control group without regard for the relative age of the child and compare changes in stunting rates across all ages of children. However, because stunting outcomes are determined in utero as well as early in life, it is important to ensure that the control group is made up of children who are the same relative age as those children who are treated. To remedy this problem, we 'stack' the data by cohort, following Cengiz et al. (2019) and Deshpande and Li (2019). The procedure is as follows. First, we define each cohort by the year in which units are treated, e.g., 2009, 2010, 2011, 2012, 2013, and 2014. Then, for each cohort, we define all households within a given radius as the treated group for that cohort year and all households that are 50 km or further away as our control households. We do this for each treatment cohort. We then 'stack' the data to align each cohort based on the relative age of children in that cohort, which is defined as the number of years that have passed since a project was completed. Children born within one year prior to a project's completion are assigned a relative age of -1, children born within the year of a project's completion are assigned a relative age of 0, and so on.

We then estimate the following difference-in-differences equation:

$$y_{hitc} = \beta D_{hitc} + \alpha_{cd} + \delta_{ct} + \tau_{ca} + \Omega_{htc} + \mu_{itc.} \quad (2)$$

This equation is similar to equation (1) except for the additional subscript c which designates the cohort-specific values of the variables. In order to eliminate heterogeneity in treatment effects across cohorts, we use district-cohort and time-cohort fixed effects. We also include relative age-cohort fixed effects, τ_{ca}, to control for any fixed level of stunting that may occur at a given relative age and is unrelated to the effects of WASH aid projects.

This stacked approach gives us the benefit of having a well-defined control group, and β is now a measure of the effect of WASH aid proximity on stunting rates relative to a control group which is 50 km or more away. Further, it is also robust to treatment effect heterogeneity that results in the negative weight issue flagged in the recent difference-in-differences literature[3] (Borusyak et al. 2021; De Chaisemartin and d'Haultfoeuille 2020; Goodman-Bacon 2021; Sun and Abraham 2021).

In order to explore heterogeneity in the effectiveness of WASH aid by age, we expand the relative age of the children in the treated group. First, we compare children who are born one year before project completion (i.e., those with a relative age of -1) to children born within a year of a project's completion (i.e., those with a relative age of 0), then to those children who are born within two years of a project's completion (i.e., those with a relative age of 1), and lastly to children born within three years of a project's completion (i.e., those with a relative age of 2). This approach enables us to determine the overall effect of WASH aid on stunting rates for the sample of infants and young children as a whole.

5 Results

5.1 Before–after comparison

Figure 4 depicts graphical evidence of the effect of WASH aid. It shows, for radii between 5 km and 30 km, the mean stunting rate for children born one year prior to the completion of a WASH aid project (i.e., relative age of -1), within one year of completion of a WASH aid project (relative age of 0), and within two years of the completion of an aid project (relative age of 1) with red, green, and blue bars, respectively. For radii up to 30 km, there is a large and considerable drop in stunting rates for children born within a year of project completion (relative age of 0): children

[3] In the canonical difference-in-differences model with staggered timing, the estimated treatment effect is a weighted average of all possible two-way difference-in-differences estimates nested in the staggered model. This can result in comparisons between already-treated units and newly treated units which can lead to negative weights if treatment effects are heterogeneous (Borusyak et al. 2021; de Chaisemartin and D'Haultfœuille 2020; Goodman-Bacon 2021; Sun and Abraham 2021).

with a relative age of 0 have generally lower stunting rates compared to those born a year prior to project completion (relative age of -1). This drop is greatest for distances closer to an aid project, and tapers off as the distance increases, to the point where there is little difference in stunting rates between children with a relative age of 0 and children with a relative age of -1 when using a 30 km radius.[4] The results are less clear for children with relative age of 1. At 5 km, stunting rates are higher among children with a relative age of 1 compared to children with a relative age of -1. However, it is important to note that the sample size for 5 km radius is relatively small.

[Figure 1 near here]

Table 3 presents the estimation results of equation (1), comparing stunting rates before and after a project completion for children born within a year of project completion (i.e., relative age is 0). The specifications include district- and year-fixed effects but no control variables. As can be seen, there is a statistically significant drop in stunting rates at the 10 km and 15 km radii. For 20 km to 30 km, the coefficients have the expected sign, but are smaller in magnitude and not statistically significant. The large coefficient for the 5 km radius is statistically insignificant, mainly because there are too few observations.

Table 4 repeats the analysis in Table 3 but with the addition of controls for household wealth, location, and the gender and education of the household head. The results do not change substantially. Only children within 10 km and 15 km see a statistically significant drop in stunting, with an estimated effect size between a 17 per cent and 24 per cent reduction in the probability of being stunted. With the exception of household size, the covariates in Table 4 are of the correct sign but are not statistically significant.

[Table 3 near here]

[Table 4 near here]

5.2 Results with a control group

As discussed above, the simple pre–post comparison lacks a control group and therefore does not account for changes in stunting that may occur due to unobserved factors. The results presented here rely upon the stacked approach for defining a control group as discussed in Section 4.

Tables 5, 6, and 7 present the results for the stacked specification at 5 km to 30 km radii without control variables for a treated sample that includes children born within a year of project

[4] Figure A1 shows an additional pre-treatment relative age of -2. Generally, stunting rates for those of relative age -2 are higher than for relative age 0, slightly lower compared to relative age -1, and more mixed compared to relative age 1.

completion in Table 5, within two years of project completion in Table 6, and within three years of project completion in Table 7.

[Table 5 near here]

[Table 6 near here]

[Table 7 near here]

Across the different age pools, proximity to a WASH aid project results in statistically significant reduced stunting rates for children within 10 km and 15 km of an aid project. However, the effect is largest for children born within a year of the completion of the project. The results in Table 5 suggest that for children in this cohort, (relative age of 0) living within a 10 km and 15 km radius of a WASH aid project, WASH aid reduces the probability of a child being stunted by 25 per cent and 15 per cent, respectively. The results in Table 6 suggest that for children born within two years of project completion (relative age of 1), the probability of stuntedness drops by 19 per cent and 12 per cent, respectively. For children born within three years of project completion (relative age of 2), the probability of being stunted drops by 19 per cent at 10 km and about 10 per cent for children within a 15 km radius, although this latter figure is only marginally statistically significant.

Tables 8, 9, and 10 present the results for the full specification including control variables.

[Table 8 near here]

[Table 9 near here]

[Table 10 near here]

When control variables are incorporated, as seen in Table 8, for children born within one year of project completion, WASH aid reduces stunting rates for children within 10 km and 15 km by 21 per cent and 12 per cent, respectively. The covariates, which are statistically significant, are generally of the expected sign. Household head primary education, urban status, and metal wall and roof have negative and statistically significant coefficients for most of the radii. The indicator for a spell of no food has a positive and statistically significant effect as well. The effect of ownership of non-agricultural land is wrong-signed, but only statistically significant for 10 km and 20 km and higher. At other radii besides 10km and 15km, there is no statistically significant effect of WASH aid project completion.

Table 9 presents the results for children born within two years of project completion. The results in this table suggest that WASH aid reduces stunting rates for children within 10 km of a WASH project by 14 per cent. For the 15 km radius, the treatment effect is no longer statistically significant. Lastly, for children born within three years of project completion, the results in Table 10 are very similar to those in Table 9. WASH aid reduces stunting rates for children within 10 km of a project by 14 per cent, and no statistically significant effect is discernible at the other radii.

6 Robustness Check

A key assumption underlying the difference-in-differences estimator is that prior to treatment, both treated and untreated households exhibit parallel trends. One possible violation of this assumption in the research design implemented here is that WASH aid projects may not be randomly distributed across the country. For example, it may be the case that households in districts with particularly poor water and sanitation outcomes may be more likely to receive a project than other households in the country.

To test for robustness against the likely non-random assignment of aid projects, we estimate a version of equation 2 using Inverse Propensity Score (IPW) weights. The procedure is as follows: first, we estimate the probability of being treated at a given radius as a function of a household's pre-treatment values for improved water access, improved toilet access, as well as the covariates used above along with district fixed effects. Then, we compute the inverse propensity score by assigning treated units a value of 1, and control units a value of $P/(1-P)$, where P is the probability of being treated as computed from the first-stage model. These weights are then included in the regression model outlined in equation 2, omitting the household wealth variables. The IPW procedure explicitly gives more weight in the estimation to households which have a high probability of being treated but were not treated, and lower weights to households which had more acceptable WASH pre-treatment outcomes. This allows us to partially mitigate the selection concerns associated with the spatial allocation of aid projects.

The IPW DiD regressions are estimated for 10km – 25km radii, and for cohorts born zero to three years after treatment, including each additional cohort successively. The results for the variable of interest are presented in Table 11. As can be seen, the coefficient estimates for the treatment effect of WASH aid projects remain highly statistically significant and in fact increase in size relative to the baseline results across all cohort groups. This is especially true for the 15km radius, although this size of the increases diminishes as the age cohort is expanded. This suggests that our results are qualitatively robust to this type of selection.

[Table 11 near here]

7. Conclusion

This paper sought to investigate the impact of foreign aid on the probability of child stunting in Uganda using geocoded sub-national data on the location of WASH aid projects combined with data from nationally representative household-level panel surveys. The empirical results indicate that aid-funded WASH projects have the potential to reduce the likelihood of stunting among children. Specifically, the results indicate that for children born within a year of project completion and living within 10 km of an aid project, WASH aid reduces the probability of stunting by between 14 and 21 per cent. For children within 15 km of an aid project, this effect shrinks to 11 per cent. These results may be interpreted in the light of results from our previous work using the same data which showed that aid-funded WASH projects do increase access to improved water sources. The evidence in this paper suggests that better access to improved water and sanitation reduces the frequency of the infections that contribute to malnourishment and stunting among children.

The positive effect of proximity to WASH aid stunting is greatest when we focus on the cohort of children born within a year of project completion and diminishes in magnitude as the age cohorts are expanded to include children born between two and three years of project completion. A possible reason for this is that WASH aid may be less effective for the older children in this cohort, perhaps because other factors such as nutrition become more important for stunting outcomes later in life. Alternatively, WASH aid may have a smaller impact on stunting for the youngest children in the expanded cohorts, i.e., those born more than a year after project completion, possibly because of inadequate maintenance of WASH projects due to lack of funding and technical capacity. Further research is needed to explore the reasons for these results.

There are some limitations to the analysis presented in this paper. First, while the AidData dataset identifies the precise location of the project, details on the nature of the project at each location were available only for a few projects. It was not possible to identify exactly what kind of improved water and sanitation infrastructure was constructed for all projects. Secondly, the analysis in the paper does not directly examine the quality, affordability, and long-term functionality of the aid-funded WASH infrastructure, all of which would be important if these health benefits are to persist. Third, it is possible that there are other water and sanitation projects that are funded by the government or by other funding sources that are not captured in our data. If these projects are present in the areas that we define as 'treated' then our estimates may be overstating the effect of aid-funded WASH projects on child stunting. If these projects are present in the areas that we define as 'untreated' then our estimates may be understating the effect of aid-funded WASH projects. In the absence of data on other WASH projects not funded by aid or captured by our dataset, the evidence from this study, therefore, cannot conclusively establish a causal link between WASH aid and health outcomes. Nevertheless, our findings provide a strong basis for further exploration of the links between WASH aid and health outcomes.

Data Availability Statement

The data and replication code used to generate the findings of this study are openly available in the Harvard Dataverse repository and can be found at the following persistent link: https://doi.org/10.7910/DVN/96O6I7.

Declaration of Competing Interests

The authors report that there are no known competing financial or non-financial interests to declare.

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References

AidData (2016). 'UgandaAIMS_GeocodedResearchRelease_Level1_v1.4.1 geocoded dataset'. Williamsburg, VA and Washington, DC: AidData (accessed 2021-06-28).

AidData (2017). 'Geocoding Methodology (Version 2.0.2)'. Available at: http://docs.aiddata.org/ad4/files/geocoding-methodology-updated-2017-06.pdf (accessed 2021-06-28).

Alabaster, R.O., and L. Kručková (2015). *Uganda Country Mapping: The Status of Implementation and Monitoring of the Human Right to Water and Sanitation*. Geneva: WaterLex. Available at: https://www.swisswaterpartnership.ch/project/uganda-country-mapping-status-implementation-monitoring-human-right-water-sanitation/ (accessed 7 November 2022).

Bain, R., R. Luyendijk, and J. Bartram (2013). 'Universal Access to Drinking Water'. WIDER Working Paper 2013/88. Helsinki: UNU-WIDER.

Bartram, J., and S. Cairncross (2010). 'Hygiene, Sanitation, and Water: Forgotten Foundations of Health'. *PLoS Medicine,* 7(11): e1000367. https://doi.org/10.1371/journal.pmed.1000367

Borusyak, K., X. Jaravel, and J Spiess (2021). 'Revisiting Event Study Designs: Robust and Efficient Estimation'. *arXiv preprint, arXiv:2108.12419*.

Botting, M.J., E.O. Porbeni, M.R. Joffres, B.C. Johnston, R.E Black, and E.J. Mills (2010). 'Water and Sanitation Infrastructure for Health: The Impact of Foreign Aid'. *Globalization and Health,* 6(1): 1–8. https://doi.org/10.1186/1744-8603-6-12

Burr, P. (2019). *The State of WASH Financing in Eastern and Southern Africa: Uganda Country Level Assessment*. Available at: https://www.unicef.org/esa/sites/unicef.org.esa/files/2019-10/UNICEF-Uganda-2019-WASH-Financing-Assessment.pdf (accessed 7 November 2022).

Cengiz, D. A. Dube, A. Lindner, and B. Zipperer (2019). 'The Effect of Minimum Wages on Low-wage Jobs'. *The Quarterly Journal of Economics,* 134(3): 1405–54. https://doi.org/10.1093/qje/qjz014

Cumming, O., and S. Cairncross (2016). 'Can Water, Sanitation and Hygiene Help Eliminate Stunting? Current Evidence and Policy Implications'. *Maternal & Child Nutrition,* 12 (S1): 91–105. https://doi.org/10.1111/mcn.12258.

DANIDA (2019). *Evaluation of Water, Sanitation and Environment Programmes in Uganda (1990-2017)*. Copenhagen: Ministry of Foreign Affairs of Denmark. Available at: https://um.dk/en/danida/results/eval/eval_reports/evaluation-of-water-sanitation-and-environment-programmes-in-uganda-1990-2017-20190314t155600 (accessed 7 November 2022).

De Chaisemartin, C., and X. d'Haultfoeuille (2020). 'Two-way Fixed Effects Estimators with Heterogeneous Treatment Effects'. *American Economic Review,* 110(9): 2964–96. https://doi.org/10.1257/aer.20181169

Deshpande, M., and Y. Li (2019). 'Who is Screened Out? Application Costs and the Targeting of Disability Programs'. *American Economic Journal: Economic Policy,* 11(4): 213–48. https://doi.org/10.1257/pol.20180076

Dreher, A., and S. Lohmann (2015). 'Aid and Growth at the Regional Level'. *Oxford Review of Economic Policy,* 31(3–4): 420–46. https://doi.org/10.1093/oxrep/grv026

Esrey, S.A., J.P. Habicht, M.C.Latham, D.G. Sisler, and G. Casella (1988). 'Drinking Water Source, Diarrheal Morbidity, and Child Growth in Villages with Both Traditional and Improved Water Supplies in Rural Lesotho, Southern Africa'. *American Journal of Public Health,* 78(11): 1451–55. https://doi.org/10.2105/AJPH.78.11.1451

Fewtrell, L., R.B. Kaufmann, D. Kay, W. Enanoria, L. Haller, and J.M Colford Jr. (2005). 'Water, Sanitation, and Hygiene Interventions to Reduce Diarrhoea in Less Developed Countries: a Systematic Review and Meta-analysis'. *The Lancet Infectious Diseases,* 5(1): 42–52. https://doi.org/10.1016/S1473-3099(04)01253-8

Fink, G., I. Günther, and K. Hill (2011). 'The Effect of Water and Sanitation on Child Health: Evidence from the Demographic and Health Surveys 1986-2007'. *International Journal of Epidemiology,* 40(5): 1196–204. https://doi.org/10.1093/ije/dyr102

Gasana, J., J. Morin, A. Ndikuyeze, and P. Kamoso (2002). 'Impact of Water Supply and Sanitation on Diarrheal Morbidity Among Young Children in the Socioeconomic and Cultural Context of Rwanda (Africa)'. *Environmental Research,* 90(2): 76–88. https://doi.org/10.1006/enrs.2002.4394

Goodman-Bacon, A. (2021). 'Difference-in-differences with Variation in Treatment Timing'. *Journal of Econometrics,* 225(2): 254–77. https://doi.org/10.1016/j.jeconom.2021.03.014

Gopalan, S., and R.S. Rajan (2016). 'Has Foreign Aid Been Effective in the Water Supply and Sanitation Sector? Evidence from Panel Data'. *World Development,* 85: 84–104. https://doi.org/10.1016/j.worlddev.2016.04.010

Gyimah-Brempong, K. (2015). 'Do African Countries Get Health from Health Aid?'. *Journal of African Development,* 17(2): 83–114. https://doi.org/10.5325/jafrideve.17.2.0083

Headey, D., and G. Palloni (2019). 'Water, Sanitation, and Child Health: Evidence from Subnational Panel Data in 59 Countries'. *Demography,* 56(2): 729–52. https://doi.org/10.1007/s13524-019-00760-y

Ndikumana, L., and L. Pickbourn (2017). 'The Impact of Foreign Aid Allocation on Access to Social Services in Sub-Saharan Africa: The Case of Water and Sanitation'. *World Development,* 90: 104–14. https://doi.org/10.1016/j.worlddev.2016.09.001

Odokonyero, T., R. Marty, T. Muhumuza, A.T. Ijjo , and G.O. Moses (2018). 'The Impact of Aid on Health Outcomes in Uganda'. *Health Economics,* 27(4): 733–45. https://doi.org/10.1002/hec.3632

OECD (2020). *Creditor Reporting System, 1990-2020*. Available at: https://stats.oecd.org/Index.aspx?DataSetCode=crs1# (accessed 2022-03-23).

Pickbourn, L., R. Caraher, and L Ndikumana (2022). 'Does Project-level Foreign Aid Increase Access to Improved Water Sources? Evidence from Household Panel Data in Uganda'. *World Development,* 158: 105994. https://doi.org/10.1016/j.worlddev.2022.105994

Pickbourn, L., and L. Ndikumana (2013). 'Impact of Sectoral Allocation of Foreign Aid on Gender Equity and Human Development'. WIDER Working Paper 2013/066. Helsinki: UNU-WIDER.

Pickbourn, L., and L. Ndikumana (2019). 'Does Health Aid Reduce Infant and Child Mortality from Diarrhoea in Sub-Saharan Africa?'. *The Journal of Development Studies,* 55(10): 2212–31. https://doi.org/10.1080/00220388.2018.1536264

Prüss-Ustün, A., J. Bartram, T. Clasen, J.M. Colford Jr, O. Cumming, V. Curtis, S. Bonjour, A.D. Dangour, J. De France, L. Fewtrell, M.C. Freeman, B. Gordon, P.R. Hunter, R.B. Johnston, C. Mathers, D..Mäusezahl, K. Medlicott, M. Neira, M. Stocks, J. Wolf, and S. Cairncross (2014). 'Burden of Disease from Inadequate Water, Sanitation and Hygiene in Low- and Middle-income Settings: A Retrospective Analysis of Data from 145 Countries'. *Tropical Medicine and International Health,* 19(8): 894–905. https://doi.org/10.1111/tmi.12329

Prüss-Ustün, A., R. Bos, F. Gore, and J. Bartram (2008). *Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health.* Geneva: World Health Organization. Available at: https://apps.who.int/iris/handle/10665/43840 (accessed 7 November 2022).

Sun, L., and S. Abraham (2021). 'Estimating Dynamic Treatment Effects in Event Studies with Heterogeneous Treatment Effects'. *Journal of Econometrics,* 225(2): 175–99. https://doi.org/10.1016/j.jeconom.2020.09.006

Tsimpo, C., and Q. Wodon (eds) (2018). *Water and Sanitation in Uganda.* A World Bank Study. Washington, DC: World Bank.

UBOS (Uganda Bureau of Statistics) (2009). *Uganda National Panel Survey (UNPS) 2005-2009*. UGA_2005-2009_UNPS_v02_M. Available at: https://microdata.worldbank.org/index.php/catalog/1001 (accessed 2021-06-28).

UBOS (Uganda Bureau of Statistics) (2011). *Uganda National Panel Survey (UNPS) 2010-2011*. Ref. UGA_2010_UNPS_v02_M. . Available at: https://microdata.worldbank.org/index.php/catalog/2166 (accessed 2021-06-28).

UBOS (Uganda Bureau of Statistics) (2012). *Uganda- National Panel Survey (UNPS) 2011-2012*. Ref. UGA_2011_UNPS_v01_M. Available at: https://microdata.worldbank.org/index.php/catalog/2059 (accessed 2021-06-28).

UBOS (Uganda Bureau of Statistics) (2014). *Uganda- National Panel Survey (UNPS) 2013-2014*. Ref. UGA_2013_UNPS_v02_M. Available at: https://microdata.worldbank.org/index.php/catalog/2663 (accessed 2021-06-28).

UBOS (Uganda Bureau of Statistics) (2016). *Uganda National Panel Survey (UNPS) 2015-2016*. Ref. UGA_2015_UNPS_v02_M. Available at: https://microdata.worldbank.org/index.php/catalog/3460 (accessed 2021-06-28).

UN (2021). *The Sustainable Development Goals Report 2021*. New York, NY: United Nations. Available at: https://unstats.un.org/sdgs/report/2021/The-Sustainable-Development-Goals-Report-2021.pdf (accessed 7 November 2022)

UNICEF/WHO (2019). *Progress on Household Drinking Water, Sanitation and Hygiene 2000-2017: Special Focus on Inequalities*. New York, NY: United Nations Children's Fund (UNICEF) and World Health Organization. Available at: https://www.unicef.org/reports/progress-on-drinking-water-sanitation-and-hygiene-2019 (accessed 7 November 2022).

UN-Water (2021). *Summary Progress Update 2021 – SDG 6 – Water and Sanitation for All*. Geneva: Switzerland. Available at: https://www.unwater.org/publications/summary-progress-update-2021-sdg-6-water-and-sanitation-for-all/ (accessed 7 November 2022).

UN-Water andWHO (2017). *UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS) 2017 Report: Financing Universal Water, Sanitation and Hygiene Under the Sustainable Development Goals:*. Geneva: World Health Organization. Retrieved from https://www.unwater.org/publications/un-water-glaas-2017-financing-universal-water-sanitation-hygiene-sustainable-development-goals/ (accessed 7 November 2011).

UN-Water andWHO (2019). *UN-Water Global Analysis and Assessment of Sanitation and Drinking Water (GLAAS) 2019 Report: National Systems to Support Drinking-Water, Sanitation and Hygiene*. Geneva: World Health Organization. Available at: https://www.unwater.org/publications/un-water-glaas-2019-national-systems-to-support-drinking-water-sanitation-and-hygiene-global-status-report-2019/ (accessed 7 November 2022).

USAID (United States Agency for International Development) (2021). *Uganda: Nutrition Profile*. Available at: https://www.usaid.gov/sites/default/files/documents/Copy_of_tagged_Uganda-Nutrition-Profile.pdf (accessed 7 November 2022).

Vincenty, T. (1975). 'Direct and Inverse Solutions of Geodesics on the Ellipsoid with Application of Nested Equations'. *Survey Review*, 23(176): 88–93. https://doi.org/10.1179/sre.1975.23.176.88

Waller, A., M. Lakhanpaul, S Godfrey; and P. Parikh (2020). 'Multiple and Complex Links Between BabyWASH and Stunting: An Evidence Synthesis'. *Journal of Water, Sanitation and Hygiene for Development*, 10(4): 786–805. https://doi.org/10.2166/washdev.2020.265

Wayland, J. (2013). 'A Drop in the Bucket? The Effectiveness of Foreign Aid in the Water, Sanitation, and Hygiene (WASH) Sector'. 'MA Thesis. Washington, DC: American University. Available at: http://hdl.handle.net/1961/16922 (accessed 7 November 2022).

Wayland, J. (2017). 'Constraints on Foreign Aid Effectiveness in the Water, Sanitation, and Hygiene (WaSH) Sector'. *Journal of Water, Sanitation and Hygiene for Development*, 8(1): 44–52. https://doi.org/10.2166/washdev.2017.095

Wayland, J. (2019). 'Constraints on Aid Effectiveness in the Water, Sanitation, and Hygiene (WASH) Sector: Evidence from Malawi'. *African Geographical Review*, 38(2): 140–56. https://doi.org/10.1080/19376812.2017.1340169

WHO (2014). *Global Nutrition Targets 2025: Stunting Policy Brief.* Geneva: World Health Organization. Available at: https://www.who.int/publications/i/item/WHO-NMH-NHD-14.3 (accessed 7 November 2022).

WHO and UNICEF (2021). *Progress on Household Drinking Water, Sanitation and Hygiene 2000-2020: Five Years into the SDGs*. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF). Available at: https://www.who.int/publications/i/item/9789240030848 (accessed 7 November 2022).

Wolf, S. (2007). 'Does Aid Improve Public Service Delivery?'. *Review of World Economics,* 143(4): 650–72. https://doi.org/10.1007/s10290-007-0126-8

Tables

Table 1: Distribution of aid projects by year of completion

Project end year	Number of project locations
2009	3
2010	2
2011	10
2012	15
2013	17
2014	1

Source: Authors' construction from AidData and Pickbourn et al. (2022) data.

Table 2: Distance to closest WASH project by region

Region	Average minimum distance to closest project (km)
Kampala	6.7
Central	49.9
Eastern	31.6
Northern	57
Western	39.5
Year	
2005	191.1
2009	60.7
2010–11	57.7
2011–12	53.5
2013–14	43.8
2015–16	43.8

This table reports the average minimum distance of households across these years. For example, if a household is 0.5 km to a 2009 project, 10 km to a 2010 project, etc., the minimum of these figures will be the closest distance to an aid project at any point. We then compute the regional average across households. Source: Authors' construction from Pickbourn et al, (2022), Uganda Bureau of Statistics, and AidData data.

Table 3: Before–after comparison for children born within one year of project completion

	Dependent variable: Stunted					
	5 km	10 km	15 km	20 km	25 km	30 km
	(1)	(2)	(3)	(4)	(5)	(6)
Aid project distance	-0.132	-0.242*	-0.188**	-0.047	-0.078	-0.010
	(0.158)	(0.124)	(0.088)	(0.083)	(0.067)	(0.065)
Observations	41	88	149	213	268	302
Adjusted R^2	0.273	0.086	0.131	0.163	0.127	0.094

Note: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the household level reported in parentheses. Source: Authors' calculations from Uganda Bureau of Statistics and AidData data.

Table 4: Before–after comparison for children born within one year of project completion with controls

	Dependent variable: Stunted					
	5 km	10 km	15 km	20 km	25 km	30 km
	(1)	(2)	(3)	(4)	(5)	(6)
Aid project distance	0.011	-0.243*	-0.174**	-0.034	-0.045	0.014
	(0.197)	(0.131)	(0.084)	(0.082)	(0.066)	(0.064)
Household size	-0.100*	-0.056**	-0.054***	-0.031*	-0.004	0.009
	(0.050)	(0.025)	(0.020)	(0.018)	(0.014)	(0.013)
Household head primary education	-0.112	-0.012	0.094	-0.062	-0.129*	-0.153**
	(0.140)	(0.142)	(0.100)	(0.084)	(0.074)	(0.076)
Household head female	-0.294	-0.159	-0.052	0.077	0.072	0.128
	(0.191)	(0.173)	(0.139)	(0.101)	(0.080)	(0.077)
Urban	-0.290	-0.013	-0.056	-0.204*	-0.165	-0.098
	(0.301)	(0.215)	(0.129)	(0.117)	(0.114)	(0.098)
Remittances	-0.272	-0.223	0.295	0.174	0.040	0.076
	(0.186)	(0.188)	(0.373)	(0.215)	(0.241)	(0.251)
Metal roof	-0.083	-0.149	-0.110	-0.105	-0.091	-0.068
	(0.251)	(0.218)	(0.158)	(0.144)	(0.105)	(0.090)
Non-agricultural land	-0.186	-0.216	-0.261**	-0.118	-0.063	-0.042
	(0.282)	(0.178)	(0.128)	(0.103)	(0.101)	(0.100)
No food	0.101	0.002	0.208	0.066	-0.044	-0.098
	(0.136)	(0.171)	(0.134)	(0.103)	(0.103)	(0.095)
Observations	41	84	139	200	251	281
Adjusted R^2	0.430	0.084	0.174	0.188	0.127	0.103

Note: p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the household level reported in parentheses. Source: Authors' calculations from Uganda Bureau of Statistics and AidData data.

Table 5: Stacked differences regression estimates for children born within one year of project completion

	Dependent variable: Stunted					
	5 km	10 km	15 km	20 km	25 km	30 km
	(1)	(2)	(3)	(4)	(5)	(6)
Aid project distance	-0.241	-0.247***	-0.150**	-0.046	-0.020	0.026
	(0.147)	(0.081)	(0.063)	(0.060)	(0.055)	(0.053)
Observations	1,478	5,531	5,394	5,319	5,208	5,095
Adjusted R^2	0.024	0.065	0.064	0.064	0.064	0.061

Note: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the household level reported in parentheses. Source: Authors' calculations from Uganda Bureau of Statistics and AidData data.

Table 6: Stacked differences regression estimates for children born within two years of project completion

	Dependent variable: Stunted					
	5 km	10 km	15 km	20 km	25 km	30 km
	(1)	(2)	(3)	(4)	(5)	(6)
Aid project distance	-0.131	-0.192***	-0.115**	-0.074	-0.038	0.001
	(0.150)	(0.071)	(0.056)	(0.051)	(0.047)	(0.045)
Observations	1,606	7,341	7,137	7,031	6,858	6,692
Adjusted R^2	0.025	0.062	0.062	0.061	0.061	0.058

Note: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the household level reported in parentheses. Source: Authors' calculations from Uganda Bureau of Statistics and AidData data.

Table 7: Stacked differences regression estimates for children born within three years of project completion

	Dependent variable: Stunted					
	5 km	10 km	15 km	20 km	25 km	30 km
	(1)	(2)	(3)	(4)	(5)	(6)
Aid project distance	-0.131	-0.187***	-0.098*	-0.053	-0.018	0.026
	(0.150)	(0.069)	(0.055)	(0.047)	(0.044)	(0.042)
Observations	1,606	8,575	8,305	8,179	7,975	7,778
Adjusted R^2	0.025	0.056	0.055	0.053	0.053	0.052

Note: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the household level reported in parentheses. Source: Authors' calculations from Uganda Bureau of Statistics and AidData data.

Table 8: Stacked differences regression estimates for children born within one year of project completion with controls

	Dependent variable: Stunted					
	5 km	10 km	15 km	20 km	25 km	30 km
	(1)	(2)	(3)	(4)	(5)	(6)
Aid project distance	-0.233	-0.214**	-0.117*	-0.039	0.001	0.043
	(0.177)	(0.086)	(0.069)	(0.063)	(0.058)	(0.054)
Household size	0.002	0.002	0.002	0.002	0.002	0.001
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Household head primary education	-0.073**	-0.039**	-0.039**	-0.044**	-0.040**	-0.042**
	(0.033)	(0.017)	(0.017)	(0.017)	(0.017)	(0.018)
Household head female	0.035	0.036	0.035	0.039	0.044*	0.036
	(0.042)	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)
Urban	-0.117***	-0.090***	-0.096***	-0.087***	-0.088***	-0.093***
	(0.044)	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)
Remittances	-0.013	0.031	0.041	0.043	0.052	0.037
	(0.095)	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)
Metal roof	-0.053	-0.066***	-0.067***	-0.072***	-0.068***	-0.058**
	(0.050)	(0.023)	(0.024)	(0.024)	(0.024)	(0.025)
Metal wall	-0.180*	-0.203***	-0.203***	-0.192***	-0.194***	-0.201***
	(0.094)	(0.059)	(0.059)	(0.060)	(0.061)	(0.061)
Generator	0.112	-0.079	-0.065	-0.069	-0.054	-0.055
	(0.175)	(0.064)	(0.066)	(0.067)	(0.070)	(0.071)
Non-agriculture land	0.052	0.021	0.015	0.020	0.030	0.032
	(0.047)	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
No food	0.077*	0.048**	0.052***	0.051***	0.039**	0.040**
	(0.040)	(0.019)	(0.019)	(0.019)	(0.020)	(0.020)
Observations	1,309	4,703	4,573	4,513	4,425	4,316
Adjusted R^2	0.042	0.072	0.071	0.072	0.072	0.069

Note: *p**p***p<0.01. Standard errors clustered at the household level reported in parentheses.
Source: Authors' calculations from Uganda Bureau of Statistics and AidData data.

Table 9: Stacked differences regression estimates for children born within two years of project completion with controls

	Dependent variable: Stunted					
	5 km	10 km	15 km	20 km	25 km	30 km
	(1)	(2)	(3)	(4)	(5)	(6)
Aid project distance	-0.113	-0.144*	-0.074	-0.057	-0.014	0.022
	(0.154)	(0.074)	(0.059)	(0.053)	(0.049)	(0.046)
Household size	0.001	0.002	0.002	0.002	0.002	0.001
	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Household head primary education	-0.064**	-0.032**	-0.034**	-0.038**	-0.036**	-0.039**
	(0.031)	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)
Household head female	0.042	0.025	0.027	0.030	0.035*	0.031
	(0.040)	(0.019)	(0.020)	(0.020)	(0.020)	(0.021)
Urban	-0.118***	-0.086***	-0.091***	-0.082***	-0.082***	-0.089***
	(0.043)	(0.020)	(0.020)	(0.020)	(0.020)	(0.021)
Remittances	0.050	0.032	0.031	0.026	0.037	0.024
	(0.098)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)
Metal roof	-0.053	-0.059***	-0.060***	-0.063***	-0.059***	-0.050**
	(0.047)	(0.020)	(0.021)	(0.021)	(0.021)	(0.021)
Metal wall	-0.186**	-0.235***	-0.235***	-0.229***	-0.233***	-0.239***
	(0.092)	(0.057)	(0.056)	(0.056)	(0.057)	(0.058)
Generator	0.143	-0.025	-0.014	-0.019	0.004	0.008
	(0.168)	(0.055)	(0.058)	(0.059)	(0.062)	(0.063)
Non-agriculture land	0.070	0.024	0.019	0.022	0.030	0.032*
	(0.045)	(0.018)	(0.019)	(0.019)	(0.019)	(0.019)
No food	0.083**	0.062***	0.063***	0.062***	0.049***	0.050***
	(0.037)	(0.016)	(0.016)	(0.017)	(0.017)	(0.017)
Observations	1,428	6,299	6,107	6,023	5,881	5,724
Adjusted R^2	0.042	0.069	0.069	0.068	0.067	0.065

Note: *p**p***p<0.01. Standard errors clustered at the household level reported in parentheses.
Source: Authors' calculations from Uganda Bureau of Statistics and AidData data.

Table 10: Stacked differences regression estimates for children born within three years of project completion with controls

	Dependent variable: Stunted					
	5 km	10 km	15 km	20 km	25 km	30 km
	(1)	(2)	(3)	(4)	(5)	(6)
Aid project distance	-0.113	-0.142**	-0.060	-0.044	-0.009	0.033
	(0.154)	(0.072)	(0.058)	(0.049)	(0.045)	(0.043)
Household size	0.001	0.002	0.002	0.002	0.002	0.0002
	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Household head primary education	-0.064**	-0.039***	-0.042***	-0.046***	-0.044***	-0.046***
	(0.031)	(0.013)	(0.014)	(0.014)	(0.014)	(0.014)
Household head female	0.042	0.021	0.023	0.025	0.030	0.023
	(0.040)	(0.018)	(0.018)	(0.018)	(0.019)	(0.019)
Urban	-0.118***	-0.091***	-0.093***	-0.085***	-0.086***	-0.092***
	(0.043)	(0.018)	(0.018)	(0.019)	(0.019)	(0.019)
Remittances	0.050	0.018	0.013	-0.0001	0.007	-0.004
	(0.098)	(0.042)	(0.042)	(0.043)	(0.043)	(0.042)
Metal roof	-0.053	-0.060***	-0.062***	-0.063***	-0.058***	-0.052***
	(0.047)	(0.019)	(0.019)	(0.019)	(0.019)	(0.020)
Metal wall	-0.186**	-0.231***	-0.235***	-0.231***	-0.237***	-0.242***
	(0.092)	(0.054)	(0.052)	(0.052)	(0.053)	(0.054)
Generator	0.143	-0.005	0.001	-0.002	0.017	0.020
	(0.168)	(0.053)	(0.055)	(0.056)	(0.059)	(0.061)
Non-agriculture land	0.070	0.030*	0.026	0.032*	0.038**	0.039**
	(0.045)	(0.017)	(0.017)	(0.018)	(0.018)	(0.018)
No food	0.083**	0.066***	0.065***	0.065***	0.055***	0.057***
	(0.037)	(0.015)	(0.015)	(0.015)	(0.016)	(0.016)
Observations	1,428	7,383	7,130	7,029	6,859	6,674
Adjusted R^2	0.042	0.066	0.065	0.064	0.064	0.062

Note: *p**p***p<0.01. Standard errors clustered at the household level reported in parentheses.
Source: Authors' calculations from Uganda Bureau of Statistics and AidData data.

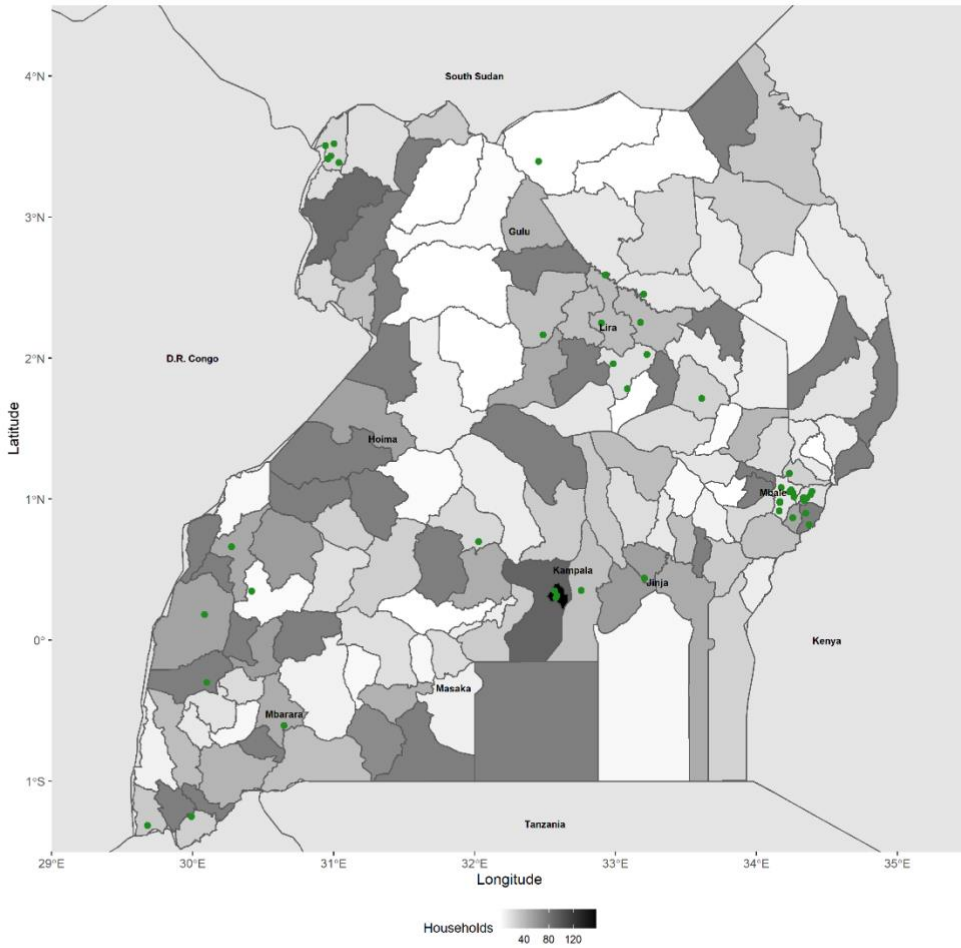
Table 11: Results from IPW difference-in-difference regressions

	Dependent variable:			
	Stunted			
	10km	15km	20km	25km
	(1)	(2)	(3)	(4)
Aid project distance - children born within one year of project completion	-0.490**	-0.617***	-0.040	-0.114
	(0.244)	(0.161)	(0.190)	(0.145)
Aid project distance – children born within two years of project completion	-0.601***	-0.599***	-0.096	-0.084
	(0.218)	(0.166)	(0.150)	(0.122)
Aid project distance – children born within three years of project completion	-0.578***	-0.562***	0.054	-0.112
	(0.221)	(0.173)	(0.162)	(0.156)

Note: *p**p***p<0.01. Standard errors clustered at the household level reported in parentheses.
Source: Authors' calculations from Uganda Bureau of Statistics and AidData data.

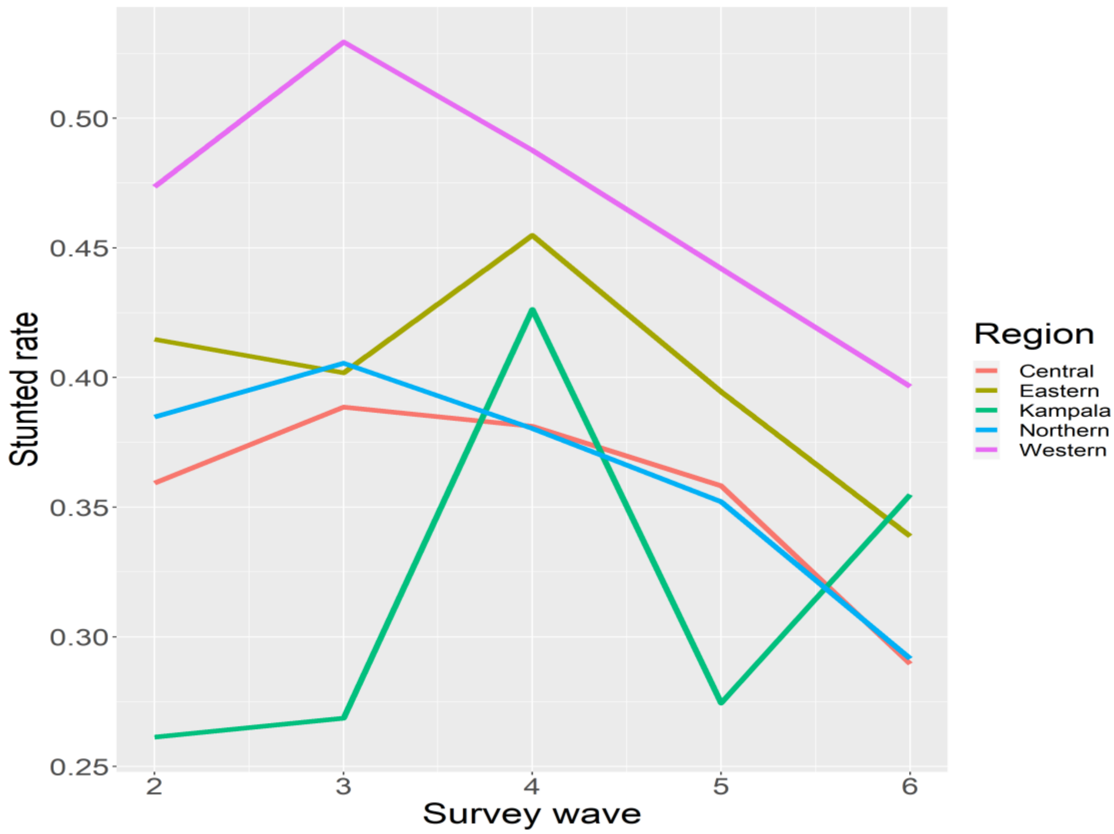
Figures

Figure 1: Location of water and sanitation projects



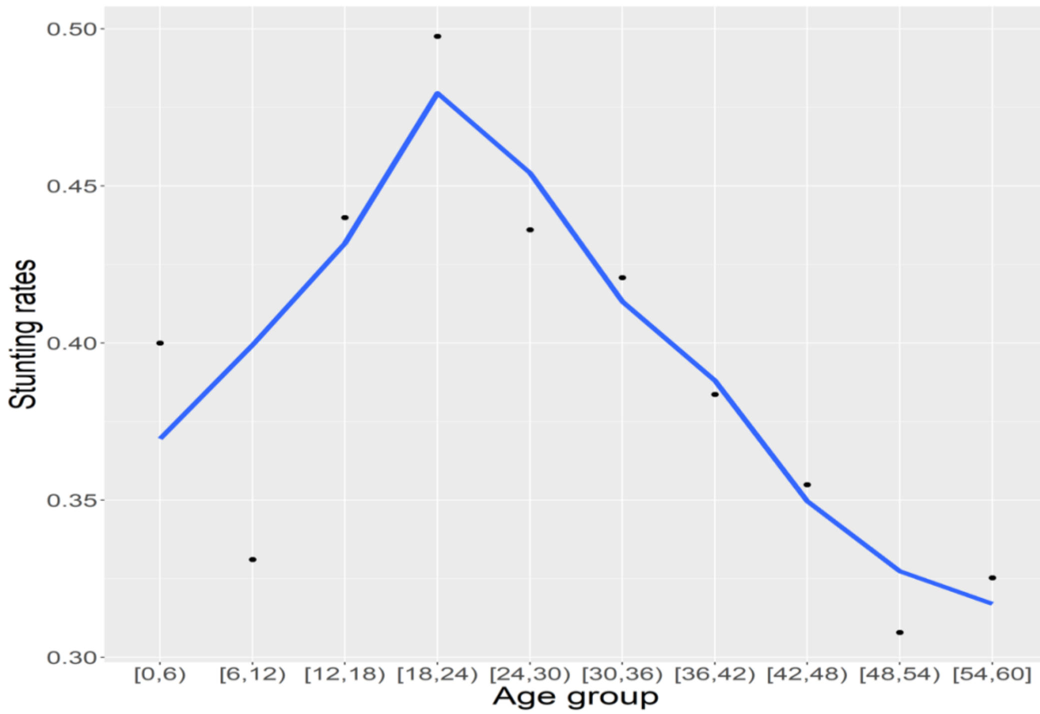
Note: this figure plots the location of geo-located WASH aid projects along with the number of households in each district. Each dot represents a completed aid project, and the shading of the districts represents the number of households in each district included in the survey data. Source: Authors' construction based on Pickbourn et al. (2022), Uganda Bureau of Statistics, and AidData data.

Figure 2: Stunting rates by region and survey wave



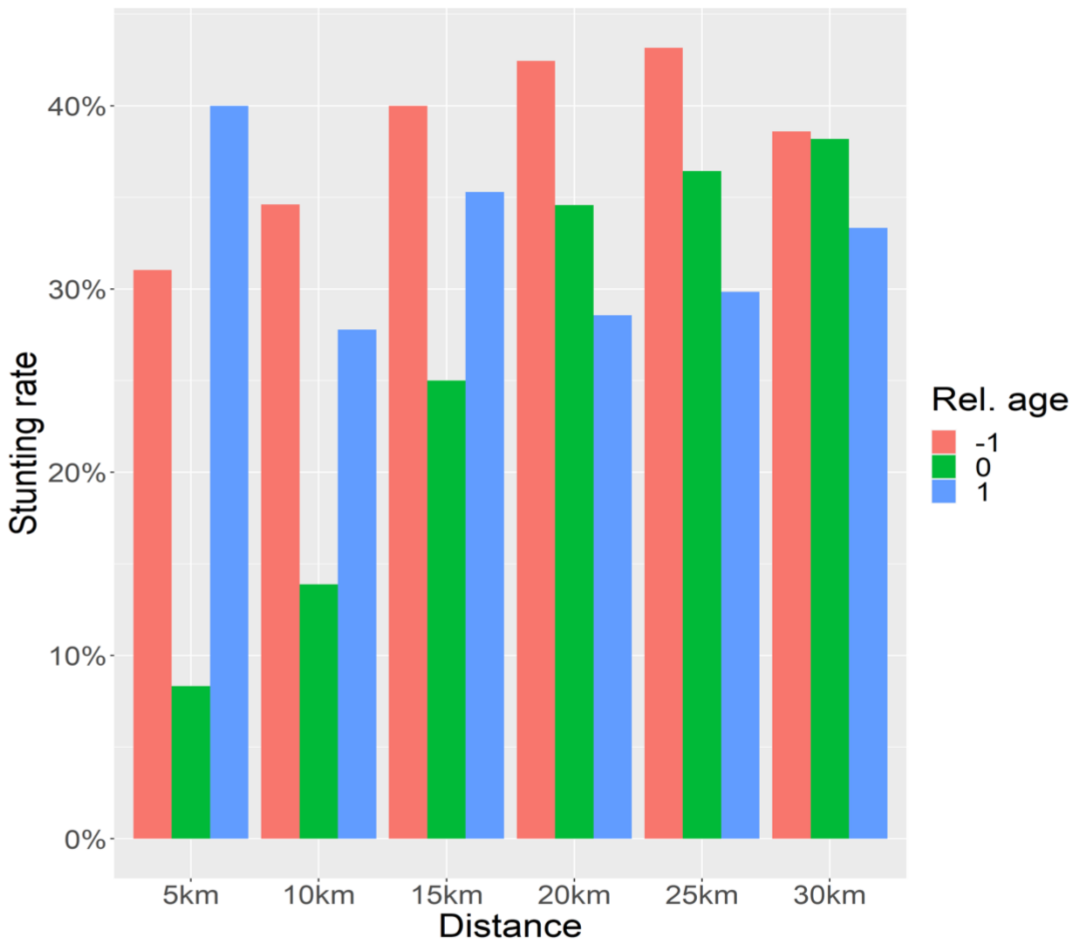
Source: Authors' construction from Uganda Bureau of Satistics and AidData data.

Figure 3: Stunting rates by age group



Source: Authors' construction from Uganda Bureau of Satistics and AidData data.

Figure 4: Mean stunting rates by relative age



Source: Authors' construction from Uganda Bureau of Statistics and AidData data.

Appendix

Table A1: Trends in WASH ODA to Uganda, 1990–2020

ODA category	1990–94	1995–99	2000–04	2005–09	2010–14	2015–20
Average total ODA disbursements (millions of 2019 USD)	52.09	199.08	1,044.25	2,377.45	1,640.56	2,001.53
Average WASH ODA disbursements (millions of 2019 USD)	6.763	14.56	63.3	84.17	71.35	118.28
Average WASH disbursements share of total (%)	9.9%	7.4%	6.5%	4.6%	4.3%	5.9%
Average WASH disbursements per capita (2019 USD)	0.35	0.68	2.52	2.86	2.05	2.85

Source: Authors' compilation from OECD-DAC database and Pickbourn et al. (2022).

Table A2: Variable definitions

Variable	Question	Coding
Household head primary education	What was the highest grade/class that [NAME] completed?	1 if the household head for a family completed primary school, 0 otherwise
Household head female	Sex	1 if the household head is female, 0 otherwise
Urban	-	1 if the household lives in an urban area, 0 otherwise
Remittances	Has the household received any income (in cash & in kind) from remittances from abroad in the past 12 months?	1 if the household has received any remittances from abroad, 0 otherwise
Metal roof	What is the major construction material of the roof?	1 if the household has an iron sheet or tin roof, 0 otherwise
Metal wall	What is the major construction material of the external wall?	1 if the household has iron or tin walls, 0 otherwise
Motor vehicle	Does any member of your household own a motor vehicle at present?	1 if the household owns a motor vehicle, 0 otherwise
Generator	Does any member of your household own a generator at present?	1 if the household owns a generator, 0 otherwise
Non-agricultural land	Does any member of your household own non-agricultural land at present?	1 if the household owns non-agricultural land, 0 otherwise
Stunted	-	1 if the child is stunted according to the WHO height-to-age standards; 0 otherwise; see https://www.who.int/tools/child-growth-standards/standards/length-height-for-age
No food	Have you been faced with a situation when you did not have enough food to feed the household in the last 12 months?	1 if the household has been in a situation where they were unable to feed the household within the last 12 months, 0 otherwise

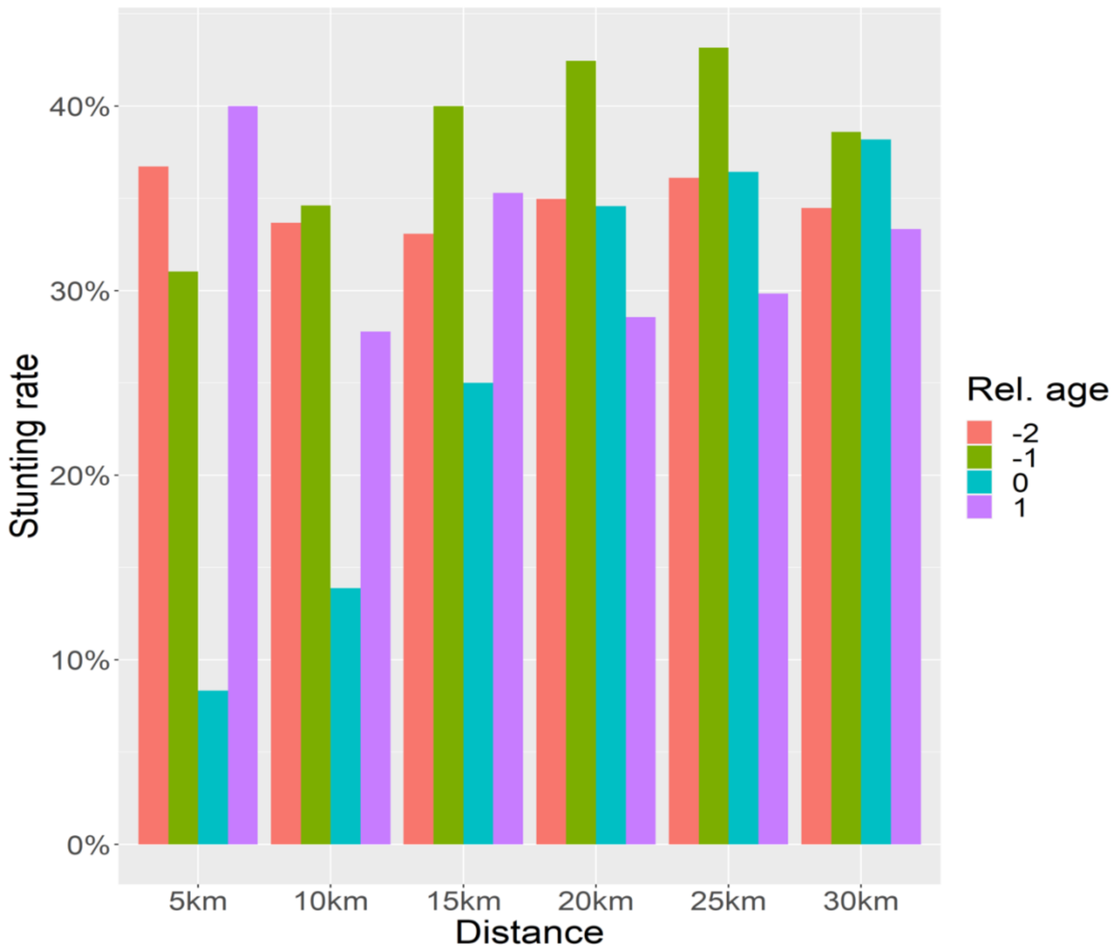
Source: Authors' compilation from Ugandan Bureau of Statistics and Pickbourn et al. (2022).

Table A3: Water and sanitation projects in Uganda with precise locations: commitments and disbursement (USD)

Title	Number of locations	Disbursements	Split-even disbursements
Emergency water supply and sanitary facilities for returning populations in Lira and Kitgum	3	Na	Na
Integrated Drylands Development Programme (IDDP) – support for the implementation of United Nations Convention to Combat Desertification (UNCCD) in the context of TERAFRICA initiative	1	Na	Na
Kampala Urban Poor Sanitation project	3	11,250,217	3,750,072
National Environment Management Authority (NEMA)	9	15,358,697	1,706,522
Territorial approach to climate change	13	98,184	5,776
The project for improvement of access to safe water and sanitation in Kyakarafa parish, Kamwenge district	1	61,459	61,459
The project for improvement of access to safe water for returnees in Lira and Dokolo district	5	58,295	11,659
The project for improvement of access to safe water in 17 schools in Koboko district	5	86,678	14,446
The project for improvement of access to safe water in Bukomero town in Kiboga district	1	71,235	71,235
The project for improvement of access to safe water in Rubirizi district	1	86,467,189	86,467,189
The project for improvement of access to safe water in Sironko district	1	52,701,249	52,701,249
The project for improvement of access to safe water in three districts in Lango sub-region	2	62,906	12,581
The project for improving access to safe water in Mbale district	2	80,956	40,478
The project for installing rainwater harvesting tanks in Kisoro district	1	84,904	84,904

Source: Authors’ construction from AidData and Pickbourn et al. (2022) data.

Figure A1: Mean stunting rates by relative age from two years prior to project completion



Source: Authors' construction from Uganda National Bureau of Statistics and AidData data.